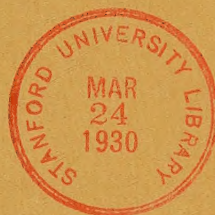


# BLOOD PRESSURE CHANGES IN DECEPTION



BY  
MATTHEW N. CHAPPELL,

L. G.

Submitted in partial fulfillment of the requirements for the degree  
of Doctor of Philosophy, in the Faculty of Philosophy,  
Columbia University

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## BLOOD PRESSURE CHANGES IN DECEPTION

The detection of deception by means of physiological changes was first undertaken by Benussi<sup>1</sup> in 1914. He found that changes in respiration usually indicated deception. No one followed Benussi's lead until Burt<sup>2</sup> in 1921 repeated it and somewhat improved the technique. In the meantime Marston,<sup>3</sup> then at Harvard, conceived the idea of using blood pressure as a criterion of deception. His technique, which we shall discuss later in this paper, was essentially that employed by Benussi in the earlier work. Burt, in 1921<sup>2</sup> repeated the work of Marston and found the blood-pressure method highly reliable. Landis and Gullette,<sup>4</sup> in 1926 could find no evidence that the pressure changes were of value in detecting deception. Careful reading reveals that the differences between the latter work and that of Marston are not as great as they seem at first glance.

In his investigations Marston used the Tycos Indicating Sphygmomanometer and the auscultatory method of taking pressure readings. His situation was one in which the subject might assume himself to be guilty or innocent of an alleged crime. In working up the data he treated each subject individually. The rise in pressure which he uses is the highest reading above the initial pressure. He concludes from his results:

- (1) That the consciousness of an attitude of deception is the key to the changes in pressure.
- (2) That a rise of 12mm. is significant of deception.
- (3) That deception can be detected by the pressure change with accuracy of 90-100%.
- (4) That "a uniform and significant systolic pressure curve was established by the results as symptomatic of the

---

<sup>1</sup> Benussi, V. (*Archiv. fur die gesamte Psychol.*) 1914, 244-273 (47).

<sup>2</sup> Burt, H. E. (*Jour. Exp. Psych.*) 1921, IV 1-23 (27), (49), (58).

<sup>3</sup> Marston, W. (*Jour. Exp. Psych.*) 1917.

<sup>4</sup> Landis & Gullette (*Jour. Comp. Psych.*) 1926.



deceptive consciousness. A rather surprising secondary result was the appearance of an almost equally definite truth curve."

This last conclusion is open to question in the light of the two individual curves given in his report, those of subjects C and G. There is certainly no uniformity apparent in these either in height of the rise or the shape of the curve. The only similarity is that they both do show a rise.

Landis and Gullette also used the Tycos instrument and the auscultatory method. Their subjects were accused of a hypothetical crime and tested twice, once when they assumed themselves guilty and again when they assumed themselves to be innocent. They treated their data not individually but found group changes. All the truth readings for all the subjects were added together and the group average for truth was determined. The data for deception were treated in the same manner and these two group averages were subtracted to find the difference in pressure between truth and deception. This difference was found to be 3mm. The accuracy of the method in differentiating truth from deception was found to be 82%. They conclude from their data "that it was impossible to set up difference in pressure as a criterion of differentiation between truth and falsehood."

The results of Landis and Gullette cannot be compared with those of Marston for the experiments have little in common. The former made their situation as artificial as possible, eliminating emotion instead of injecting it into the situation as Marston did. The treatment of their results was very different from that of Marston. By averaging their group data they have effectively blanketed all individual changes. Further, the difference of the group averages can be readily controlled by the length of the individual test since the excitement in so artificial a situation will be of short duration. The blanketing effect on large changes will be shown later in this report. Their data as taken are not reported. It is, therefore, not possible to determine accurately what the effect of individual treatment would be, but some indication may be gained by inspection of the individual curves presented. These are all grouped in two charts. They show the subject's variability to be somewhat greater when lying than while



telling the truth. In the truth series only three of the twenty-two subjects show rises of 8mm. or more, whereas in the deception series eight subjects show such a rise. Finally, their conclusion that it is impossible to set up pressure differences as diagnostic of deception is not justified by their own results, which show the chances of a reliable difference to be eighty-two in one hundred. When all things are considered it seems quite possible that if Landis and Gullette had used individual treatment of their data their results might have given strong support to some of Marston's contentions.

Following the work of Marston, Larson at the Police School in Berkeley, California devised a method of detecting deception in which he obtained continuous records of circulatory changes in the arm. Just what phenomenon of circulation is recorded by this instrument is not clear. It is a high pressure plethysmograph and records volume changes in the arm of a type somewhat different from the volume changes recorded by the low pressure plethysmograph. That it does not record lateral pressure is shown by data obtained by the present experimenter which are as yet unpublished. For this reason we shall not consider the work of Larson in this paper.

### APPARATUS

Two types of instruments were used in this investigation—the Tycos indicating and the Tycos recording sphygmomanometers. A conical stethoscope was used with the indicating instrument to hear the sound of flow through the brachial artery. The Tycos indicating sphygmomanometer is the instrument used by Marston and Landis. It has a single chamber cuff which may be adjusted to the arm or leg. When this is inflated the pressure is indicated on a dial by means of a pointer attached to an aneroid diaphragm. This instrument only indicates and does not record any pressure. Its use involves an observer and the accuracy of the readings obtained varies somewhat with variations of his acuity of hearing.

The second instrument is described in a booklet published by the Taylor Instrument Company. It is purely mechanical, easily operated and cannot be greatly influenced by the observer. With this a record is made in ink on a rotating paper disc similar to those used in taking continuous records of air

and steam pressure in industrial plants except that the pressure is indicated circumferentially rather than radially. The disc is driven by the movement of an aneroid diaphragm which covers the pressure chamber. This chamber is also connected directly to the cuff. In this fashion the chart shows at all times the cuff pressure. This cuff has two chambers so connected that as the air slowly escapes after inflation, the upper chamber is always at a slightly lower pressure than the one below. The pressure in the upper chamber is the same as that behind the aneroid diaphragm which controls the position of the chart. The lower chamber is connected to another aneroid diaphragm which drives the pen. Due to the difference of pressure in the two chambers of the cuff the blood passes the upper chamber at the point of the lateral pressure, which just counterbalances the cuff pressure, and surges against the lower chamber. This causes a slight increase in the pressure in this chamber. The surge is transmitted to the pen through the aneroid diaphragm causing it to move radially. The first radial line appearing on the chart is the point of lateral pressure. As the air leaks out of the cuff the amplitude of the pen increases for a period and then decreases. Usually there is a quick decrease and sometimes a point appears at which two of the radial lines are of about equal amplitude. This has been taken empirically by the Taylor Instrument Company to be the point of diastolic pressure. Unfortunately the criterion of diastolic pressure does not appear in all subjects. The instrument makes a record only of the intermittent phenomena and does not take a continuous record of the changes. Several records may be made on one chart and the curve of the changes plotted directly on it.

## THE CIRCULATORY SYSTEM

To understand the variety of changes which may occur in blood pressure it is necessary to have some knowledge of the vascular system. Let us, therefore, briefly point out the major factors governing the changes in the normal individual.

The heart, with the arteries and veins forms a closed system in which circulates a comparatively constant amount of



blood at an average pressure of about 110 to 140mm. of mercury, depending upon the age.

In speaking of blood pressure it is necessary to specify what pressure is meant since there are five different kinds: namely, systolic, diastolic, pulse, mean and lateral. By systolic is meant that pressure which is developed during the systole or the contraction of the heart which drives the blood from the left ventricle in to the general system. By diastolic is meant the pressure in the arterial system at the closure of the semilunar valves at which time occurs the diastole or expansion of the heart. By pulse pressure is meant the difference between the diastolic and the systolic or that portion which drives the blood through the system. By mean is indicated the average of the systolic and diastolic pressures. By lateral is meant the pressure against the arterial walls at any point.

Some confusion has arisen from the failure of investigators to indicate and properly define the pressure with which they have worked. Particularly have systolic and lateral pressures been confused. It is impossible to obtain systolic blood pressure except by the use of the manometer and the stromuhr simultaneously; that is, there are two components in which the energy of the contraction is expended, namely, velocity head and pressure head.<sup>5</sup> The stromuhr measures the velocity and the manometer the pressure head. Since the use of these instruments involves an incision in the arteries, needless to say they are not used with human subjects. Still many papers may be found purporting to deal with systolic pressure. If we could use systolic pressure the problem would be relatively simple since we would not be dealing with those factors outside of the heart which cause the lateral pressure to vary. That is, we would be concerned only with the decrease and increase of the heart activity and could eliminate the influence of the vaso-motor system. What passes for systolic pressure in the human being is more properly lateral pressure. To call this systolic is misleading for it is not necessarily directly proportional to the pressure of the systole. Since it is with lateral pressure that we are dealing let us consider just what factors influence its change.

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<sup>5</sup> Burton-Opitz,<sup>2</sup> Textbook of Physiology.



First, it may be influenced by an increase or decrease in the force of the heart beat or, force remaining constant, by the rate of the beat. Second, it may be raised by any major vaso-constriction or lowered by any major vaso-dilation. Third, a change in the quantity of blood circulating may raise or lower the pressure depending upon the direction of the change. The third factor is of no importance to our investigation since over one quarter of the total amount of blood must be lost before any marked change in pressure occurs. So far as we know none of our subjects lost any blood.

Those effects coming directly from the heart action are governed by two sets of nerve fibers which originate in the medulla.<sup>6</sup> These are called the augmentor and inhibitor fibers. They are efferent in nature. The augmentor fibers leave the spinal cord in the anterior roots of the second and third and probably the fourth thoracic nerves. They reach the sympathetic chain through the white rami communicantes running up through the stellate ganglion and the annulus of Vieussens to the inferior cervical ganglion. From here they pass off to the heart by separate accelerator branches. The inhibitor fibers leave the medulla in the roots of the eleventh, or spinal accessory nerve which joins the roots of the tenth or vagus. They pass down the vagus in two bundles, one through the superior and the other through the inferior cardiac ramus to the plexus cardiacus located on the arch of the aorta where also are found the augmentor fibers.

Another important nerve directly connected with the heart is the depressor. It is sensory in its nature and conducts impulses from the arch of the aorta to the nucleus of the vagus and the cardiac and vasomotor centers. It gives rise to reflexes which produce a reduction in the rate of the heart beat and a dilatation of the blood vessels. It probably functions only in emergencies.

The augmentor fibers function in two ways: first to increase the rate and second, to increase the force of the heart beat. These are independent factors, the one occurring with or without the other. Excitation of the inhibitor fibers causes a decrease in the activity of the heart. The nature of this reduction is not clearly understood. It seems probable,

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<sup>6</sup> Stewart, *Manual of Physiology*.

however, that the activity of the vagus causes a liberation of some salt, possibly potassium, in the heart itself which raises the synaptic resistance or to some extent anaesthetizes the sympathetic nerve endings, thus decreasing the augmenting impulses.

If we were considering systolic blood pressure these might be the only parts of the nervous system which would interest us. However, since we are dealing with lateral pressure we must consider the excitation of the vasomotor mechanism which in itself is in a state of constant change. The vasomotor center is located in the medulla in the same region as that in which the cardiac center is found.<sup>7</sup>

Just as the muscular walls of the heart are governed by two sets of nerve fibers, a set which keeps down the rate of working and a set which may increase it, the muscular walls of the vessels are under the control of nerves which have the power of diminishing their size (vaso-constrictor) and those which have the power to increase it (vaso-dilator). These vasomotor nerves control chiefly the small arteries. They probably have no direct influence on the capillaries. The fibers seem to arise from any part of the spinal cord, the constrictors, being somewhat more restricted than the dilators. The chief vasomotor nerves are the sciatic, the brachial, the trigeminus, the cervical sympathetic, the greater splanchnic and on the afferent side only the depressor.<sup>8</sup>

In order to get a clearer conception of the integrated action of the nervous mechanism upon the circulation let us take a few hypothetical conditions. Assume the force of the heart to be  $F$  and the rate to be  $R$  and the vasomotor condition to be  $M$  (in the arm of a subject), the lateral pressure to be  $L$  and the velocity pressure to be  $V$ :

- (1) If now  $R$  and  $M$  remain constant and  $F$  increases it results in an increase of  $L$  and  $V$ , that is, the lateral pressure which we record is higher.
- (2) If  $F$  and  $R$  remain constant and  $M$  becomes  $C$  (constriction) there is a greater obstruction to the flow and a decrease in  $V$ . With a decrease in  $V$  the energy

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<sup>7</sup> Ranson, *Am. Jour. Physiol.*, 1917.

<sup>8</sup> Stewart, *Manual of Physiology*.

loss in  $V$  is converted into lateral pressure and there is, therefore, an increase in  $L$ . Again then, we record a higher lateral pressure and this time with no increase in the force of the heart beat which is systolic pressure.

- (3) If  $F$  increases and  $R$  remains constant and  $M$  becomes  $D$  (dilation) just sufficient to keep  $V$  constant, then  $L$  also will remain constant and we will have a condition in which there is a rise in systolic pressure and no rise in lateral pressure.
- (4) Many other combinations may be demonstrated. Probably the most extreme would be that in which an increase in  $F$  with a general vaso-dilation may result in a drop of lateral pressure.

The above is a simplified view of the phenomena, which probably never occurs, that is, one factor does not change while all the rest remain constant but all may change simultaneously and in any direction. For a more complete explanation of the circulation the reader may peruse any good text book of physiology.

## THE COMPARISON OF METHODS OF OBTAINING LATERAL BLOOD PRESSURE

Lateral blood-pressure may be taken by three methods, namely, the mechanical method, the auscultatory method and the palpation method.

The mechanical method is that in which the record of the pressure is obtained by purely mechanical means and is uninfluenced by the observer. The auscultatory is that in which a stethoscope is used to observe the sound caused by the flow of blood through some artery, usually the brachial. The palpation method is that in which the flow of blood is observed by placing the finger tips over the radial artery.

Previous investigators have not used the mechanical method. In order to compare work done by the different methods it is necessary to determine the relations existing between them. In this determination the Tycos Recording Sphygmomanometer was used as the standard since it is



mechanically so designed that the record of lateral pressure must be taken when blood flows past the upper cuff of the arm band.

Two series of readings were taken. In the first, simultaneous readings were obtained by the mechanical and the palpation methods, and in the second by the mechanical and auscultatory methods. All the readings in each series were taken on one subject, the interval between readings being about one minute.

The results obtained in the first series are shown in Table I and those in the second in Table II. Table I shows that the average of the thirty readings obtained by the mechanical method is 125mm. Hg. The palpation average is 107.4mm. Hg. The average difference between the two methods is 17.6mm. Hg. This means that the Tycos Recording instrument indicates the lateral pressure 17.6mm. higher than do the finger tips of this observer. This difference will vary among observers, depending probably on the sensitivity of the fingers. The  $\sigma_{dis}$  of the mechanical readings is 5.77. The  $\sigma_{ave}$  is 1.15. For the palpation method the  $\sigma_{dis}$  is 5.08 and the  $\sigma_{ave}$  is .945. The  $\sigma$  of the difference between the two is 1.43. The reliability of the difference is  $12.3\sigma$ .

It seems probable that with practice in taking the pressure by the pulse method this difference might be somewhat reduced. These readings were taken by an observer relatively unpracticed in all the methods.

Table II shows that for the mechanical method the average is 123.2mm.,  $\sigma_{dis}$  is 5.5 and  $\sigma_{ave}$  is 0.99. For the auscultatory method the average is 122.5mm.,  $\sigma_{dis}$  is 5.85 and  $\sigma_{ave}$  is 1.05. The  $\sigma$  of the difference is 1.44. The reliability of the difference is  $0.485\sigma$ .

In 23 of the 31 comparisons the readings were identical. The range of the difference is 2 to 6mm. This is very small as compared to the range of 8 to 25mm. obtained in the first series. The reliability shows that there is little or no difference between the mechanical and auscultatory methods and that they may be used interchangeably with only a very slight error which is negligible compared to the normal variations in lateral blood-pressure.

This is not the case with the palpation and mechanical

methods, however, for there exists a completely reliable difference between the two.

### THE DETECTION OF DECEPTION BY INCREASES IN LATERAL BLOOD-PRESSURE

When this work started it was the intention of the investigator to use the Tycos Recording instrument throughout the whole group of experiments. However, it became necessary to return the sphygmomanometer to the Taylor Instrument Company before the series was completed and for the latter part of the work the Tycos Indicating instrument was employed with the auscultatory method.

The subjects used were undergraduates who were taking general psychology at Seth Low Junior College of Columbia University and whose ages range from sixteen to twenty-five years. Fifty-nine subjects were employed, the majority being male Hebrews.

#### PROCEDURE

All of the work was conducted in a research room in the Physics Building at Columbia University where excellent conditions for such an experiment may be obtained. The subjects were told before they came to the room that they were to undergo a deception test. The attempt was made at this point to set up in the subjects a desire to deceive the experimenter and to prove the test a failure. How well this attempt succeeded may be indicated by the fact that out of the first thirty-three tests only three subjects chose to tell the truth.

When the subjects came to the room they were given a card on which the following was written, "At half past nine Monday morning (date) the paymaster of the National Biscuit Company was attacked and robbed at the corner of Ninety-ninth Street and Broadway. He was hit on the head with a lead pipe and five thousand dollars were taken from him. You were seen at Ninety-eighth Street and Broadway at twenty-five minutes past nine. On Friday (date) your room was searched by detectives and three thousand dollars were found under the rug. Make up an alibi that will adequately cover the situation. Remember that you must admit those things which are known about you. In this test you

may assume either that you are guilty or not guilty. If you wish to assume that you are telling the truth, that you do not know anything about the hold-up, that you are not guilty, you will use the alibi furnished by the investigator. If you wish to assume that you are guilty, that you did commit the hold-up, that you will lie and try to get away with it, you will use the alibi that you have written. Whether you assume that you are guilty or not guilty you must write an alibi."

"Do not tell the investigator what you intend to do."

"Memorize the alibi that you intend to use for you will be examined."

By having each subject write an alibi, whether or not he intended to use it, the investigator always kept on hand one that he had not heard, which might be used for truth by the subject who followed.

The instructions were repeated orally by the investigator and the subject was asked if he thoroughly understood the instructions. The investigator then left the room while the subject wrote an alibi and memorized the one he chose to use. As soon as the subject was ready he called the investigator back to the room. The subject then rolled his right shirt sleeve to his shoulder and seated himself at a table with his back to the instrument. The band was then adjusted to his right arm and inflated. The questioning began. The subject was asked his name, age, residence, telephone number and occupation outside of school hours. While these questions were being asked and answered, one and in some cases two readings were taken. Although the subject was not instructed to answer truthfully to these questions he almost always did so. In those cases in which the subject lied in answering these questions the data were omitted. Without an appreciable pause the questioning was shifted to the alibi. No rigid form of questioning was followed. To some extent the questioning depended upon the content of the alibi. In general, such questions as these were asked:

"Where were you at 9:30 o'clock on Monday morning (date)?"

"What were you doing there?"

"Did you see the hold-up?"

"Were you connected with the hold-up?"



"Did you hit the man with a lead pipe?"

"Who did?"

"What did you do with the other \$2,000?"

"Why did you hide the \$3,000?"

"Is that a lie?"

During the time these questions were being asked and answered three records were taken. The interval between readings in this and all succeeding work was one minute.

### RESULTS

The data taken for Truth are shown in Table III, those for Deception in Table IV. The first column gives the subject's initials; the second, third, fourth and fifth columns show the four readings taken on each subject. The sixth column shows the average of these. Figure IV shows the curves plotted from data in Tables III and IV.

Tables V and VI show the differences between the first and each of the three following readings. The sixth columns show the average and the seventh the greatest of these differences.

There are six ways of considering these data which are as follows:—

(1) By the use of the Absolute readings of the group.

Table III shows that the averages of the four readings for the truth group increased from 125mm. on the initial reading to 129.8mm. on the third, from which it drops to 128.5mm. The reliability of the difference between the average of first readings and that of each of the following is  $0.18\sigma$ ,  $0.90\sigma$  and  $0.69\sigma$  respectively. This means that there is an unreliable difference between that part of the test in which subjects were telling the actual truth and that in which they assumed themselves to be answering truthfully about an alleged crime.

Table IV shows that the averages of the four readings for the deception group increases steadily from 124mm. on the first reading to 143mm. on the fourth. The reliability of the differences between the average of the first and each of those following are  $1.54\sigma$ ,  $3.7\sigma$  and  $4.3\sigma$  respectively. This means that there is a completely reliable difference between readings taken during actual truth and those taken during the assumption of an attitude of deception.

## (2) By the use of average readings.

This is the way in which Landis and Gullette treated their data and is the grossest possible.

The average truth reading is found by averaging the readings in the sixth column of Table III. This is 127.4mm. The  $\sigma$  is 13.4 and  $\sigma_{\text{ave}}$  2.7. The average deception reading, found in the same way, is 134.3mm. The  $\sigma$  is 12.7 and  $\sigma_{\text{ave}}$  2.2. The difference between the averages is 6.9mm. The  $\sigma_{\text{diff}}$  is (shown in Table III) 2.58 and the reliability of the difference is  $2.46\sigma$ . There are 993 chances in 1000 that there is a difference between these groups. The figure obtained by Landis and Gullette for this was 820.

## (3) By the use of differences.

Tables V and VI show the differences between the first reading and each of the following for Truth and Deception respectively. The sixth columns show the averages, the seventh the greatest of these differences.

In the truth group the difference between the first and each of the three following is 1, 5, and 3.5mm. respectively. The corresponding sigmas are 3.66, 5.8 and 8.1, and  $\sigma_{\text{ave}}$  is 0.752, 1.16 and 1.6.

In the deception group the difference between readings 1 and 2 is 7mm. The  $\sigma$  is 7.8 and  $\sigma_{\text{ave}}$  is 1.33. The difference between readings 1 and 3 is 15mm., with a  $\sigma$  of 8.9 and  $\sigma_{\text{ave}}$  of 1.53. The difference between readings 1 and 4 is 20mm., with a  $\sigma$  of 10.3 and  $\sigma_{\text{ave}}$  of 1.77. The  $\sigma_{\text{diff}}$  between the averages of the differences of similar readings in the Truth and Deception groups is found in Table VI. [ $\sigma(\text{diff})$  (n&n)] as are the reliabilities of these differences. The reliability of the difference between the averages of the changes in the case of the first readings is indeterminate and is assumed to be 0.<sup>9</sup> The reliability increases to  $4\sigma$ ,  $5.2\sigma$ , and  $6.9\sigma$  respectively in the following averages.

## (4) By use of the Average Difference.

Instead of using the averages of the differences between the first and each of the three following readings the average of all the differences may be used. These are shown in the sixth columns of Tables V and VI. These show the average

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<sup>9</sup> That this assumption is warranted is shown by the very low reliability of the difference between the averages of initial readings in Tables III and IV.

change for Truth to be 2.3mm., with a  $\sigma$  of 3.6, a  $\sigma_{ave}$  of 0.72 and the average for Deception to be 10.5mm. with a  $\sigma$  of 5.8 and a  $\sigma_{ave}$  of 1.0. The reliability of the difference between these averages, shown in Table V, is 6.8  $\sigma$ .

(5) By use of the Greatest Difference.

If, instead of the Average Difference Columns we use the seventh columns of Tables V and VI, which show the greatest differences and treat them as in the preceding case, the reliability of the difference between the averages of the greatest differences in the two groups is 6.65 $\sigma$ .

(6) By means of Overlapping of the two groups.

In all of the above ways of treating the data we are working with the reliability of a difference between the two groups. These measures, no matter how great the  $R(\text{diff})$  is found to be, tell nothing of the accuracy with which truth and deception are differentiated. This can be determined best by the overlapping of the greatest differences in the two groups. Figure I shows the greatest differences for each of the subjects of the Truth group, plotted above the axis and those for the subjects of the Deception group plotted below. This diagram shows that the greatest accuracy is obtained if 13mm. is taken as the critical pressure. Five subjects who assumed the attitude of deception show less and three who chose that of truth show more than the critical pressure. The accuracy of the differentiation is 87%.

Figure II shows the outstanding individual difference in the blood pressure curves obtained from the truth group and Figure III those from the deception group. In considering these, the outstanding feature is the wide range of variation. In deception the initial pressure ranges from 100 to 166mm. No two curves are identical or even very similar. There are 34 subjects in the deception group and, with very gross classification nine kinds of curves are found. This classification is according to slope alone and is irrespective of the general level of the curve.

Subjects AB and LO conform to curve 1 in which the level is fairly constant through the first three readings with a rise on the fourth. Subjects HC and JO showed results similar to curve 2 in which the high point comes in the 2nd reading followed by a decrease to a constant level. Subjects AN, WK, CZ, IR, EB, RC, IL, HL, AN, HSm, MH, HS, NP, EW and



FR gave curves somewhat similar to 3 in which there was an increase in each succeeding reading from the first to the fourth. Subjects BM, GM, and JE gave curves similar to 4 in which there was an alternating direction of slope. Subjects TK, IS and AH gave curves similar to 5 in which there is a rise to the 3rd point followed by a fall on the fourth. Subjects EF, MK, BMi, TL, NG gave curves similar to 6 in which the pressure was constant through the first 2 readings followed by a rise to the fourth. Curve 7 is plotted from the results of subject LB in which the pressure decreases from the first to a constant level. Subjects PF and GS gave curves similar to 8 in which there is a rise from the first to the 3rd reading where it becomes constant. Subjects ME and PK gave curves similar to 9 in which there is a fall in the 2nd followed by a rise in the 3rd and 4th readings.

If any of these curves were to be taken as typical it would probably be curve 3 to which 15 of the subjects conform more or less closely. In the light of the number of different kinds of curves obtained it would probably be better to say there is no typical deception curve unless we mean by that the curve drawn from the averages which is shown in Figure IV.

In the truth group Figure II we find much the same sort of a condition existing. Subjects AK, AS and AW had changes similar to those shown in curve 1 in which there is a slight rise in the 2nd and 3rd points with a decrease on the 4th. Subjects ASt, SG, Tn and GP had changes similar to that shown in curve 2 in which the pressure is fairly constant in the 1st and 2nd readings and rises on the 3rd and 4th. Subjects IR, KD, IK, BSm, HJ and BS gave results similar to curve 3 in which the pressure was fairly constant throughout. Subjects BS and HJ had changes similar to those shown in curve 4. Curve 4 was plotted on the results obtained with subject BS in which the pressure decreases to a constant level on the 3rd and falls on the 4th readings. Subjects IL, JK and WC had changes similar to those shown in curve 5 in which there is a rise from the 1st to a constant level in the 2nd, 3rd and 4th readings. Subjects VD and MG had changes similar to those shown in curve 6 in which the pressure remains constant to the 3rd and drops on the 4th reading. Subjects CK and JD had changes similar to those shown in curve

7 in which the slope alternates. Subjects JT, BJ and JS had changes similar to those shown in curve 8 in which the pressure rises from the 1st to the 4th readings. Curve 9 was plotted from data obtained from subject MR in which the pressure rose to the 2nd and fell to the 4th reading. Here again with gross classification we find 9 kinds of curves in the data obtained from twenty-five subjects.

In this group the initial pressure ranges from 104 to 152mm. It is evident that variation is the normal condition and that irrespective of blood pressure levels there is no really typical truth curve unless one chooses to say that a curve plotted from the group averages as shown in Figure IV is the typical truth curve.

### CONTROL EXPERIMENTS

In the experiment described above a group curve for deception has been given. This curve gives rise to three questions:

- (1) Can it be produced in any situation other than that of deception?
- (2) Will deception give such a curve under all circumstances, and
- (3) What is the cause of the rise?

To answer these it was found necessary to devise three control experiments. In the first an attempt was made to find a situation in which there was no deception but which gave a curve similar to that obtained in deception. In the second the subjects chose an attitude of truth or deception in a situation which had little or no emotional content. A third experiment was found necessary as a control for the first. In this it was shown by elimination what had caused the rise in the first.

### EXPERIMENT A

#### CHANGES OCCURRING DURING AN INTELLIGENCE TEST

In this experiment the subjects were presented with a situation which has a tendency to disturb somewhat the emotional equilibrium of most people. They were told that their intelligence was to be measured.

Throughout this work the Tycos Recording Sphygmomanometer was used to measure the blood-pressure. The "intelligence test" consisted of a multiplication sheet of two-place numbers. The eighteen subjects were a heterogeneous group all of whom were taking summer work at Columbia University. Six were instructors of psychology; one or two others were candidates for the degree of Ph. D. in psychology; the remainder were students who were taking courses in general psychology; four were women.

It was necessary to deceive the subjects to some extent in order to induce them to come to the laboratory. Few people enjoy having their intelligence measured. Therefore, they were lured to the room under the pretext of having their normal blood-pressure changes observed. This was not entirely untrue.

The subjects were seated as in the deception test with their arms resting on a table and their backs toward the instruments and the observer at their right side. The band was attached to the right arm and four readings of normal blood-pressure were taken. The investigator then said the following to each subject: "I wish to discover if there is any relation existing between the range of normal blood pressure changes and intelligence. To do this I shall now give you a battery of tests and take blood-pressure readings while you are working. The first is a test of mathematical ability. You will multiply the columns of numbers. Give your answers aloud. Work as rapidly as possible. There is a time limit and your score is computed in terms of the numbers which you complete correctly."

The phrase "battery of tests" was introduced only to make the procedure seem more forbidding. There was no test other than the multiplication sheet.

Many of the subjects objected to having such a test foisted upon them and said so in no uncertain terms. Some started to work and declared that they would not go further. A demonstration of disgust on the part of the investigator in these cases had the desired effect and the unruly subjects went on working.

Four readings were taken while the subjects worked. The interval between readings was about one minute.



## RESULTS

The data taken in this experiment are shown in Table VII. The average changes for the group are very similar to those obtained in the deception test. There is a steady increase from the 1st to the 4 readings where the pressure remains about constant. The greatest difference is between the first and the fourth averages, the difference being 15.5mm. The average of the greatest individual changes is somewhat larger, 20.6mm. as we should expect.

These rises are not as great as those obtained in the deception test. Possibly one explanation of this is the difference in the subjects used. In this group, as we have noted before, are many people who have been working in psychology for some time. Probably these have been subjects for many psychological experiments. As a result they become so accustomed to the experimental situation that they show less emotional change than does the naive subject. If we omit these subjects from the group the averages become somewhat different. The initial pressure is 113.4mm. and rises to 135.3mm. on the fourth readings, an increase of 21.9mm. The average of the greatest individual changes is 26.5mm. (Fig. V.).

These changes are somewhat larger than those obtained in the deception tests. It is needless to draw conclusions as to the quantity of the change. It is merely pointed out that the quantitative differences between the averages obtained in this experiment and those obtained in the deception experiment are not important. The slope of the curve is the same throughout both experiments. That these results are so very similar to those obtained in the deception experiment is probably accidental. The range of individual difference is again very great. The range of change is from a fall of 5mm. in the case of subject MS to a rise of 35mm. in subjects CL and KH. Subject MS is a Ph. D. candidate with whom the investigator has been closely associated for the past two years. He was quite familiar with the work that was in progress and had been a subject in other parts of the work. He multiplies very rapidly and accurately and at the end of the test said, "You should have given me something difficult—I was once a bank clerk so this is very simple to me." Subject

RN became very excited and angry during the test and said, "I can't multiply" and completed the test only upon being urged. Subject KH became disturbed and said, "You had better give me something else to do." Subject MH refused to do any of the work as soon as she was told it was an intelligence test. It seems probable that in this case there was a desire to avoid effort.

The changes were probably not all due to the same emotional conditions as we have seen in some cases there was anger and in some cases what seemed to be more closely allied to fear. In other cases the condition was probably one of excitement of the variety found in competitive situations.

No matter what caused the rise the fact is that we have produced changes similar to those obtained in the deception experiment under conditions in which the subject did not lie or have an attitude of deception. We are, therefore, justified in concluding that lying is not characteristic of the so-called lying curve.

## EXPERIMENT B

### BLOOD-PRESSURE CHANGES DURING MENTAL WORK

In the preceding experiment it was shown that large rises were obtained due to some factor present in the situation in which the subject thought his intelligence was being measured. There are two factors which may have some connection with the rise. The subjects were somewhat tense or excited and they were also doing mental work. If we can eliminate one of these factors there may be some justification in assuming that the other is the cause of the change.

This experiment was designed to test the effects of mental work which is entirely free from any excitement. The necessity of reporting in such a situation is apt to lead to some changes that would not occur if the situation were entirely free from checks and competition.

The Tycos Recording and the Tycos Indicating Instruments were used in this experiment. The multiplication sheets used in the "intelligence test" were used again in this series.

The twenty-seven subjects were undergraduates enrolled in the courses in general psychology at Seth Low Junior Col-

lege of Columbia University. The age range is from sixteen to nineteen years. The nationality is predominantly Hebrew. Four of the subjects were girls. Eleven of them were tested in the research room of the Physics Building. The remainder were tested in a small office at Seth Low.

Each subject was given the following instructions orally: "I wish to find out what effect pure mental work has upon blood pressure. I shall give you a sheet upon which are lists of numbers to be multiplied without the aid of paper or pencil. You need not tell me the answers you get nor will you be asked how many you have completed at the end of the test. I have no check on how much you do. If you do nothing I shall not know it. All that I have is your assurance that you will work hard and complete as many as possible while you are being tested." Each subject promptly assured the experimenter that he would do as many as he could. The results obtained are based solely on the assumption that the subjects did work throughout the test. Many gave objective manifestations of effort but no record was kept of these.

The subjects were seated as before and five readings were taken, one before he started to work and four while he was working. The data taken are shown in Table VIII.

## RESULTS

The averages obtained show a drop in the blood pressure from 123mm. on the first reading to 121mm. on the fifth. The pressure remained constant through the first three readings, the drop of 1mm. occurring in each of the fourth and fifth readings. The reliability of the difference between the averages of the first and fifth readings is very small. The  $\sigma_{diff}$  between one and five is 3.36; the difference is 2 and the reliability of the difference is 0.595.<sup>10</sup>

The range of variation in the change is again large from a drop of 14mm. in subject AB to a rise of 11mm. in subject MS. In eighteen of the twenty-seven subjects there was a decrease in pressure. This decrease may have been due to the fact that the subjects began the test with a very slight

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<sup>10</sup> These results agree with those of Marston on mental work. Binet and Vaschide, *L'Année Psy.* 1896, found that intense mental work caused a rise of 20m.m. Hg. Their subject reported his results as he completed each problem.



amount of excitement which disappeared as the test progressed.

The curve plotted from the averages is shown in Figure VII. The results show conclusively that the rise obtained in the intelligence test experiment was not due to the effort expended in mental work. It is then probably due to the other factor which we have noted formerly—that of agitation or excitement.

## EXPERIMENT C

### CHANGES DURING UNEMOTIONAL DECEPTION

We saw in Experiment A that the “lying curve” was found under conditions other than deception. It was further shown that a rise was due to excitement. Two questions remain to be answered: (1) What part of the rise found in the deception situation is due to excitement? and (2) How does the consciousness of lying influence the pressure? To answer these Experiment C was designed.

The Tycos Indicating instrument and the auscultatory method were used throughout this series. All readings were taken on the left arm.

The 45 subjects used were of the same type as those used in the experiment on mental work. Three were girls. Eight of the subjects were tested at Seth Low and the remainder in the Physics Building.

In this series there was no attempt to induce in the subjects any spirit of competition. Rather it was attempted to implant the impression that the deception was only incidental and of little interest to the investigator.

The subject was given a card upon which the following instructions were written: “You will be given a card on which there are listed ten objects. You will be asked the color of these objects. You must answer truthfully when asked the first five. You may answer either truthfully or falsely to the last five. Do not mix your answers. If you answer one of the last five falsely answer all five falsely. Choose whichever attitude you like. This is not a deception test.”

Before being tested each subject was asked to repeat the instructions. He then chose one of two cards on which were listed ten objects. These two cards were the same except

that the last five objects on the cards were arranged in different orders. This difference in order prevented the experimenter from recognizing the attitude assumed by the subject. It would have been much easier for the experimenter if some mechanical means had been used to make all the subjects lie, such as drawing lots to determine which attitude he would assume. It is believed by the present experimenter that forcing an attitude on the subject in such a way introduces another factor, the results of which cannot be measured.

The subjects were seated as in the previous experiments with the instrument attached to the left arm. The questioning was as follows:—"What is the color of the first object?" "What is the color of the second object?", etc. As in the other experiments the interval between readings was about one minute. In this case five readings were taken, two while the subject was responding truthfully and three while he was answering truthfully or falsely, according to the attitude which he had chosen. At the close of the series the subject was asked what attitude he had assumed.

## RESULTS

Table IX shows the data taken from the truth group; Table X those of the deception group and Table XI a summary of these. Figure VI shows the curves plotted from the averages taken from Table XI.

The curve for deception starts at 136mm. and remains practically constant to the fourth reading. Between the fourth and fifth readings there is a drop to a final pressure of 133mm.

The truth curve starts at a pressure of about 129mm., slowly increases to a little over 130mm. on the third reading from which it drops to about 129 on the fifth reading.

The reliability of the difference between the initial averages is  $1.97\sigma$ . This reliability decreases to  $0.89\sigma$  between the final averages.

The shapes of these curves are very different from those obtained in the first experiment. Probably in this case not even the difference in levels is of any significance since by omitting one subject who consistently shows a high pressure the general level of the deception curve may be lowered

about 2mm. The difference between the two is probably due for most part to chance.

The range of changes in the truth series is from a fall of 14mm. to a rise of 6mm. The range in the deception group is from a fall of 24mm. to a rise of 10mm. Only three subjects in this group showed a rise of over 4mm.

From these results it is evident that deception in itself, free from other exciting factors, does not cause the lateral blood-pressure to rise. The rise that was obtained in the first experiment must have been due to excitement. It is further evident that there is no characteristic curve for deception even when group results are used.

### SUMMARY AND CONCLUSIONS

A. We have shown in the introduction that the major difference between the work of Marston and of Landis is in the treatment of their data. Marston considered individual changes and Landis worked with the grossest of averages which blanketed any individual changes. Further, Landis' own results do not justify his conclusion.

B. In a preliminary investigation the relations between the three methods of obtaining blood-pressure were determined. The mechanical and the auscultatory methods were found to be equally accurate. The palpation method was found to be on an average of 17.6mm. less accurate for this investigator than the mechanical method. Since the mechanical and auscultatory methods are equally accurate about the same difference exists between the auscultatory and palpation methods.

C. In the deception experiment the subject was presented with a laboratory situation in which he might either lie or tell the truth. Using lateral blood-pressure as the criterion, truth and deception were differentiated with 87% accuracy. The curves obtained from individuals conform to no particular type in either truth or deception. Variation is the outstanding characteristic. However, group curves for truth and deception were drawn which show a completely reliable difference. The average rise was found to be 5.1mm. for truth and 20.8mm. for deception.

D. In the first control experiment the subject was pre-



sented with a situation which he believed to be an intelligence test. The curve obtained from the group averages was very similar to that found in the deception experiment. In this case there was no deception. Again, there is no typical curve and the range of variation is wide.

E. In the second control experiment the subject was presented with the same mental work that was performed in the first. The conditions under which he worked were designed to eliminate excitement. The curve obtained was practically a horizontal line indicating that the rises found in the second experiment were due to excitement and not to mental work .

F. In the third control experiment the subject was presented with a situation in which he might lie or tell the truth but which, unlike that of the first deception experiment, was free from exciting conditions. The curves obtained show no rise in lateral blood-pressure. Both the truth and deception curves remained practically constant in level throughout and in no way resemble those previously obtained.

From these results the following conclusions may be drawn:

- 1st. Lateral blood-pressure may be used to detect deception experimentally when the deception situation gives rise to excitement and when other causes of excitement are eliminated.
- 2nd. The "deception curve" may be obtained under conditions other than those of deception, as when subjects are told that their intelligence is being measured.
- 3rd. Mental work causes no rise in the blood-pressure and, therefore, the rise obtained in the intelligence situation is due to excitement.
- 4th. The consciousness of deception causes no change in lateral blood-pressure. The rise obtained in the first experiment is, therefore, due to excitement.
- 5th. There is no characteristic curve for deception.

## COMPARISON OF BLOOD PRESSURE METHODS

Table I.

MECHANICAL versus  
PALPATION  
Readings of Lateral Pressure

| <i>Machine</i>          | <i>Palpation</i> | <i>Difference</i> |
|-------------------------|------------------|-------------------|
| 128                     | 115              | 13                |
| 126                     | 109              | 17                |
| 134                     | 110              | 24                |
| 129                     | 112              | 17                |
| 132                     | 110              | 22                |
| 136                     | 115              | 21                |
| 130                     | 105              | 25                |
| 125                     | 106              | 19                |
| 127                     | 109              | 18                |
| 129                     | 104              | 25                |
| 136                     | 115              | 21                |
| 127                     | 105              | 22                |
| 128                     | 110              | 18                |
| 127                     | 107              | 20                |
| 120                     | 107              | 13                |
| 129                     | 115              | 14                |
| 125                     | 115              | 10                |
| 123                     | 115              | 8                 |
| 116                     | 102              | 14                |
| 123                     | 105              | 18                |
| 123                     | 103              | 20                |
| 127                     | 105              | 22                |
| 125                     | 105              | 20                |
| 120                     | 108              | 12                |
| 117                     | 108              | 9                 |
| 117                     | 100              | 17                |
| 115                     | 100              | 15                |
| 120                     | 100              | 20                |
| 112                     | 97               | 15                |
| Av.                     | 125              | 107.4             |
| $\sigma$ m              | =5.77            |                   |
| $\sigma$ (ave) m        | =1.15            |                   |
| $\sigma$ p              | =5.08            |                   |
| $\sigma$ (ave) p        | =0.945           |                   |
| $\sigma$ (diff) (m & p) | =1.43            |                   |

Reliability of the difference between  
(m) and (p)  $12.3\sigma$

Table II.

MECHANICAL versus  
AUSCULTATORY  
Readings of Lateral Pressure

| <i>Machine</i>          | <i>Ausculta</i> | <i>Difference</i> |
|-------------------------|-----------------|-------------------|
| 120                     | 120             | 0                 |
| 120                     | 120             | 0                 |
| 126                     | 124             | 2                 |
| 124                     | 122             | 2                 |
| 124                     | 122             | 2                 |
| 118                     | 118             | 0                 |
| 120                     | 118             | 2                 |
| 119                     | 115             | 4                 |
| 121                     | 121             | 0                 |
| 123                     | 121             | 2                 |
| 120                     | 120             | 0                 |
| 121                     | 121             | 0                 |
| 121                     | 121             | 0                 |
| 122                     | 122             | 0                 |
| 114                     | 114             | 0                 |
| 124                     | 124             | 0                 |
| 117                     | 117             | 0                 |
| 122                     | 122             | 0                 |
| 115                     | 115             | 0                 |
| 120                     | 120             | 0                 |
| 119                     | 117             | 2                 |
| 121                     | 121             | 0                 |
| 127                     | 127             | 0                 |
| 127                     | 212             | 6                 |
| 126                     | 126             | 0                 |
| 127                     | 127             | 0                 |
| 125                     | 125             | 0                 |
| 125                     | 125             | 0                 |
| 132                     | 132             | 0                 |
| 140                     | 140             | 0                 |
| 140                     | 140             | 0                 |
| Av.                     | 123.2           | 122.5             |
| $\sigma$ m              | =5.5            |                   |
| $\sigma$ (ave) m        | =0.99           |                   |
| $\sigma$ a              | =5.85           |                   |
| $\sigma$ (ave) a        | =1.05           |                   |
| $\sigma$ (diff) (a & m) | =1.44           |                   |

Reliability of the difference between  
(m) and (a)  $0.485\sigma$

Table III

Experiment 1

## DETECTION OF DECEPTION

Data for Truth Group—25 subjects

Readings of Lateral Blood Pressure in mm. Hg.

| <i>Subject</i>                                                        | <i>1st</i> | <i>2nd</i>    | <i>3rd</i>    | <i>4th</i>    | <i>Average Reading</i> |
|-----------------------------------------------------------------------|------------|---------------|---------------|---------------|------------------------|
| B. S.                                                                 | 140        | 137           | 137           | 129           | 136                    |
| J. T.                                                                 | 112        | 113           | 130           | 132           | 122                    |
| B. J.                                                                 | 125        | 128           | 132           | 137           | 130.5                  |
| A. St.                                                                | 141        | 137           | 148           | 152           | 144.5                  |
| J. D.                                                                 | 120        | 114           | 118           | 111           | 115.7                  |
| V. D.                                                                 | 120        | 120           | 121           | 110           | 117.7                  |
| J. S.                                                                 | 112        | 115           | 117           | 121           | 116.3                  |
| T. N.                                                                 | 114        | 114           | 117           | 124           | 117.3                  |
| H. J.                                                                 | 134        | 130           | 129           | 132           | 131.3                  |
| K. D.                                                                 | 109        | 106           | 107           | 108           | 107.5                  |
| A. W.                                                                 | 120        | 119           | 135           | 133           | 126.7                  |
| I. K.                                                                 | 128        | 128           | 128           | 130           | 128.5                  |
| I. L.                                                                 | 114        | 124           | 124           | 124           | 121.5                  |
| B. Sm.                                                                | 106        | 106           | 110           | 106           | 107.                   |
| A. S.                                                                 | 146        | 150           | 154           | 150           | 150.                   |
| J. K.                                                                 | 112        | 116           | 120           | 120           | 117.                   |
| A. K.                                                                 | 152        | 158           | 169           | 148           | 156.7                  |
| S. G.                                                                 | 126        | 126           | 134           | 136           | 130.5                  |
| W. C.                                                                 | 134        | 140           | 140           | 144           | 139.5                  |
| C. K.                                                                 | 116        | 120           | 116           | 124           | 119.                   |
| G. P.                                                                 | 118        | 118           | 124           | 130           | 122.5                  |
| I. R.                                                                 | 140        | 140           | 140           | 140           | 140.                   |
| B. C.                                                                 | 134        | 136           | 136           | 132           | 134.5                  |
| M. G.                                                                 | 148        | 148           | 152           | 140           | 147.                   |
| M. R.                                                                 | 104        | 110           | 108           | 104           | 106.5                  |
| Ave.                                                                  | 125        | 126           | 129.8         | 128.5         | 127.4                  |
| $\sigma$                                                              | 13.7       | 13.8          | 13.6          | 13.3          | 13.4                   |
| $\sigma$ (ave.)                                                       | 2.74       | 2.76          | 2.72          | 2.66          | 2.7                    |
| $r$ (1 & n)                                                           |            | .95           | .91           | .79           |                        |
| $\sigma$ (diff) (1 & n)                                               |            | 5.4           | 5.3           | 5.1           |                        |
| $R$ . (diff) (1 & n)                                                  |            | 0.18 $\sigma$ | 0.90 $\sigma$ | 0.69 $\sigma$ |                        |
| $\sigma$ (diff) between average of Average Reading (T. & D.)—2.58     |            |               |               |               |                        |
| $R$ (diff) between average of Average Reading (T. & D.)—2.46 $\sigma$ |            |               |               |               |                        |

Table IV

Experiment 1.

## DETECTION OF DECEPTION

Data for Deception Group—34 subjects

Readings of Lateral Blood Pressure in mm. Hg.

| <i>Subject</i>          | <i>1st</i> | <i>2nd</i>    | <i>3rd</i>   | <i>4th</i>   | <i>Average Reading</i> |
|-------------------------|------------|---------------|--------------|--------------|------------------------|
| W. K.                   | 113        | 130           | 137          | 140          | 130                    |
| E. F.                   | 118        | 118           | 134          | 151          | 130                    |
| M. K.                   | 100        | 98            | 113          | 116          | 107                    |
| B. Mi.                  | 134        | 132           | 153          | 158          | 144                    |
| C. Z.                   | 110        | 116           | 121          | 129          | 119                    |
| I. R.                   | 122        | 134           | 146          | 150          | 138                    |
| B. M.                   | 133        | 148           | 140          | 168          | 148.5                  |
| E. B.                   | 123        | 124           | 138          | 142          | 132                    |
| R. C.                   | 120        | 122           | 126          | 144          | 128                    |
| I. L.                   | 115        | 132           | 143          | 150          | 135                    |
| P. F.                   | 115        | 125           | 146          | 146          | 133                    |
| T. K.                   | 122        | 125           | 145          | 140          | 133                    |
| M. E.                   | 115        | 110           | 122          | 128          | 119                    |
| H. L.                   | 116        | 124           | 125          | 130          | 124                    |
| A. N.                   | 130        | 155           | 160          | 165          | 152                    |
| H. Sm.                  | 116        | 126           | 130          | 131          | 126                    |
| I. S.                   | 117        | 130           | 130          | 129          | 125                    |
| G. M.                   | 108        | 116           | 125          | 122          | 118                    |
| M. H.                   | 119        | 130           | 142          | 146          | 129                    |
| H. S.                   | 139        | 145           | 146          | 151          | 145                    |
| G. S.                   | 127        | 134           | 145          | 145          | 138                    |
| T. L.                   | 135        | 132           | 156          | 162          | 146                    |
| P. K.                   | 110        | 104           | 122          | 123          | 115                    |
| N. P.                   | 127        | 131           | 146          | 153          | 134                    |
| J. E.                   | 136        | 151           | 150          | 171          | 152                    |
| E. W.                   | 120        | 132           | 140          | 153          | 137.5                  |
| J. O.                   | 120        | 144           | 142          | 142          | 134                    |
| F. R.                   | 116        | 135           | 145          | 151          | 137                    |
| N. G.                   | 134        | 134           | 140          | 148          | 139                    |
| H. C.                   | 150        | 162           | 156          | 156          | 156                    |
| A. B.                   | 166        | 166           | 164          | 174          | 168                    |
| A. H.                   | 142        | 150           | 160          | 150          | 151                    |
| L. O.                   | 124        | 122           | 126          | 126          | 124                    |
| L. B.                   | 118        | 116           | 116          | 116          | 116.5                  |
| Ave.                    | 124        | 131           | 139          | 143          | 134.3                  |
| $\sigma$                | 12.9       | 15.2          | 13.0         | 14.8         | 12.7                   |
| $\sigma$ (ave.)         | 2.22       | 2.58          | 2.23         | 2.52         | 2.2                    |
| $r$ (1 & n)             |            | .78           | .76          | .75          |                        |
| $\sigma$ (diff) (1 & n) |            | 4.53          | 4.05         | 4.44         |                        |
| $R$ (diff) (1 & n)      |            | 1.54 $\sigma$ | 3.7 $\sigma$ | 4.3 $\sigma$ |                        |



DIFFERENCES BETWEEN THE FIRST AND EACH OF THE  
FOLLOWING READINGS FOR TRUTH

| Subject                                                                  | Difference Between First and Each of the Following Readings |      |      |     | Average Difference | Greatest Difference |
|--------------------------------------------------------------------------|-------------------------------------------------------------|------|------|-----|--------------------|---------------------|
|                                                                          | 1st                                                         | 2nd  | 3rd  | 4th |                    |                     |
| B. S.                                                                    | 0                                                           | — 3  | — 3  | —11 | —4                 | —11                 |
| J. T.                                                                    | 0                                                           | 1    | 18   | 20  | 9.7                | 20                  |
| B. J.                                                                    | 0                                                           | 3    | 7    | 12  | 5.5                | 12                  |
| A. St.                                                                   | 0                                                           | — 4  | 7    | 9   | 3                  | 11                  |
| J. D.                                                                    | 0                                                           | — 6  | — 2  | — 9 | —4.3               | — 9                 |
| V. D.                                                                    | 0                                                           | 0    | 1    | —10 | —2.3               | —10                 |
| J. S.                                                                    | 0                                                           | 3    | 5    | 9   | 4.3                | 9                   |
| T. N.                                                                    | 0                                                           | 0    | 3    | 10  | 3.3                | 12                  |
| H. J.                                                                    | 0                                                           | — 4  | — 5  | — 2 | —2.7               | — 5                 |
| K. D.                                                                    | 0                                                           | — 3  | — 2  | — 1 | —1.5               | — 3                 |
| A. W.                                                                    | 0                                                           | — 1  | 15   | 13  | 6.7                | 15                  |
| I. K.                                                                    | 0                                                           | 0    | 0    | 2   | .5                 | 2                   |
| I. L.                                                                    | 0                                                           | 10   | 10   | 10  | 7.5                | 10                  |
| B. Sm.                                                                   | 0                                                           | 0    | 4    | 0   | 1.                 | 4                   |
| A. S.                                                                    | 0                                                           | 4    | 8    | 4   | 4.                 | 8                   |
| J. K.                                                                    | 0                                                           | 4    | 8    | 8   | 5.                 | 8                   |
| A. K.                                                                    | 0                                                           | 6    | 17   | — 4 | 4.7                | 17                  |
| S. G.                                                                    | 0                                                           | 0    | 8    | 10  | 4.5                | 10                  |
| W. C.                                                                    | 0                                                           | 6    | 6    | 10  | 5.5                | 10                  |
| C. K.                                                                    | 0                                                           | 4    | 0    | 8   | 3.                 | 8                   |
| C. P.                                                                    | 0                                                           | 0    | 6    | 12  | 4.5                | 12                  |
| I. R.                                                                    | 0                                                           | 0    | 0    | 0   | 0.                 | 0                   |
| B. C.                                                                    | 0                                                           | 2    | 2    | — 2 | .5                 | 2                   |
| M. G.                                                                    | 0                                                           | 0    | 4    | — 8 | 3.0                | — 8                 |
| M. R.                                                                    | 0                                                           | 6    | 4    | 0   | 2.5                | 6                   |
| Av.                                                                      |                                                             | 1    | 5    | 3.5 | 2.3                | 5.1                 |
| $\sigma$                                                                 |                                                             | 3.66 | 5.8  | 8.1 | 3.6                | 8.8                 |
| $\sigma$ (ave.)                                                          |                                                             | .752 | 1.16 | 1.6 | 0.72               | 1.7                 |
| R (diff) between averages of Average Difference (T. & D.)—6.8 $\sigma$   |                                                             |      |      |     |                    |                     |
| R (diff) between averages of Greatest Difference (T. & D.)—6.65 $\sigma$ |                                                             |      |      |     |                    |                     |

Table VI

DIFFERENCES BETWEEN THE FIRST AND EACH OF THE  
FOLLOWING READINGS FOR DECEPTION GROUP

| Subject                 | <i>Difference Between First and Each of the<br/>Following Readings</i> |            |              |              | <i>Average<br/>Difference</i> | <i>Greatest<br/>Difference</i> |
|-------------------------|------------------------------------------------------------------------|------------|--------------|--------------|-------------------------------|--------------------------------|
|                         | <i>1st</i>                                                             | <i>2nd</i> | <i>3rd</i>   | <i>4th</i>   |                               |                                |
| W. K.                   | 0                                                                      | 17         | 24           | 27           | 17                            | 27                             |
| E. F.                   | 0                                                                      | 0          | 16           | 33           | 12                            | 33                             |
| M. K.                   | 0                                                                      | — 2        | 13           | 16           | 6.5                           | 16                             |
| B. Mi.                  | 0                                                                      | — 2        | 19           | 24           | 10                            | 24                             |
| C. Z.                   | 0                                                                      | 6          | 11           | 19           | 9                             | 19                             |
| I. R.                   | 0                                                                      | 12         | 24           | 28           | 16                            | 28                             |
| B. M.                   | 0                                                                      | 10         | 2            | 30           | 10.5                          | 30                             |
| E. B.                   | 0                                                                      | 1          | 15           | 19           | 9                             | 19                             |
| R. C.                   | 0                                                                      | 2          | 4            | 24           | 8                             | 24                             |
| I. L.                   | 0                                                                      | 11         | 28           | 35           | 20                            | 35                             |
| P. F.                   | 0                                                                      | 10         | 31           | 31           | 18                            | 31                             |
| T. K.                   | 0                                                                      | 3          | 23           | 18           | 11                            | 23                             |
| M. E.                   | 0                                                                      | — 5        | 7            | 13           | 4                             | 13                             |
| H. L.                   | 0                                                                      | 8          | 9            | 14           | 8                             | 14                             |
| A. N.                   | 0                                                                      | 25         | 30           | 35           | 22                            | 35                             |
| H. Sm.                  | 0                                                                      | 10         | 14           | 15           | 10                            | 15                             |
| I. S.                   | 0                                                                      | 13         | 13           | 12           | 8                             | 13                             |
| G. M.                   | 0                                                                      | 8          | 17           | 14           | 10                            | 17                             |
| M. H.                   | 0                                                                      | 11         | 23           | 27           | 10                            | 27                             |
| H. S.                   | 0                                                                      | 6          | 7            | 12           | 6                             | 12                             |
| G. S.                   | 0                                                                      | 7          | 18           | 18           | 11                            | 18                             |
| T. L.                   | 0                                                                      | — 3        | 21           | 27           | 11                            | 27                             |
| P. K.                   | 0                                                                      | — 6        | 12           | 13           | 5                             | 13                             |
| N. P.                   | 0                                                                      | 6          | 19           | 26           | 12                            | 26                             |
| J. E.                   | 0                                                                      | 15         | 14           | 35           | 16                            | 35                             |
| E. W.                   | 0                                                                      | 12         | 20           | 33           | 16                            | 33                             |
| J. O.                   | 0                                                                      | 24         | 22           | 22           | 17                            | 24                             |
| F. R.                   | 0                                                                      | 19         | 29           | 35           | 21                            | 35                             |
| N. G.                   | 0                                                                      | 0          | 6            | 14           | 5                             | 14                             |
| H. C.                   | 0                                                                      | 12         | 6            | 6            | 6                             | 12                             |
| A. B.                   | 0                                                                      | 0          | — 2          | 8            | 2                             | 8                              |
| A. H.                   | 0                                                                      | 8          | 18           | 8            | 9                             | 18                             |
| L. O.                   | 0                                                                      | — 2        | 2            | 2            | 0                             | 2                              |
| L. B.                   | 0                                                                      | — 2        | — 2          | — 2          | 1.5                           | — 2                            |
| Av.                     | 0                                                                      | 7          | 15           | 20           | 10.5                          | 20.8                           |
| $\sigma$                | 0                                                                      | 7.8        | 8.9          | 10.3         | 5.8                           | 9.3                            |
| $\sigma$ (ave.)         | 0                                                                      | 1.33       | 1.53         | 1.77         | 1.0                           | 1.6                            |
| $\sigma$ (diff) (n & n) |                                                                        | 1.52       | 1.92         | 2.4          |                               |                                |
| R (diff.) (n & n)       |                                                                        | 4 $\sigma$ | 5.2 $\sigma$ | 6.9 $\sigma$ |                               |                                |

Table VII

Experiment A

## INTELLIGENCE TEST

18 Subjects

Readings of Lateral Blood Pressure in mm. Hg.

| <i>Subject</i> | <i>1st</i> | <i>2nd</i> | <i>3rd</i> | <i>4th</i> | <i>5th</i> | <i>Greatest Change</i> |
|----------------|------------|------------|------------|------------|------------|------------------------|
| H. L.          | 119        | 121        | 142        | 122        | 124        | 23                     |
| J. W.          | 123        | 126        | 121        | 127        | 133        | 10                     |
| D. E.          | 119        | 120        | 144        | 134        | 132        | 25                     |
| M. S.          | 100        | 95         | 96         | 97         | 98         | —5                     |
| A. R.          | 126        | 130        | 141        | 128        | 136        | 15                     |
| R. D.          | 118        | 118        | 122        | 137        | 134        | 19                     |
| W. K.          | 111        | 114        | 122        | 126        | 123        | 15                     |
| K. T.          | 130        | 125        | 155        | 150        | 139        | 25                     |
| Y. Y.          | 131        | 131        | 157        | 153        | 151        | 26                     |
| C. L.          | 112        | 124        | 128        | 147        | 139        | 35                     |
| E. L.          | 100        | 124        | 115        | 114        | 116        | 24                     |
| L. G.          | 89         | 104        | 113        | 122        | 118        | 33                     |
| M. Y.          | 110        | 116        | 133        | 125        | 128        | 23                     |
| C. D.          | 135        | 152        | 140        | 150        | 156        | 21                     |
| M. Si.         | 115        | 116        | 124        | 110        | 110        | 9                      |
| M. H.          | 125        | 120        | 130        | 128        | 126        | 5                      |
| K. H.          | 117        | 112        | 129        | 143        | 152        | 35                     |
| R. N.          | 95         | 104        | 104        | 129        | 108        | 34                     |
| Ave.           | 115        | 119.5      | 128        | 130.5      | 129        | 21.5                   |
| $\sigma$       | 12.6       | 11.8       | 15.8       | 15.3       | 15.1       | 10.7                   |

Table VIII

Experiment B

## MENTAL WORK

27 Subjects

| <i>Subject</i> | Readings of Lateral Blood Pressure in mm. Hg. |            |            |            |            | <i>Greatest Change</i> |
|----------------|-----------------------------------------------|------------|------------|------------|------------|------------------------|
|                | <i>1st</i>                                    | <i>2nd</i> | <i>3rd</i> | <i>4th</i> | <i>5th</i> |                        |
| M. S.          | 109                                           | 120        | 115        | 110        | 110        | 11                     |
| R. N.          | 110                                           | 104        | 108        | 111        | 111        | — 6                    |
| A. W.          | 125                                           | 126        | 125        | 121        | 121        | — 4                    |
| J. D.          | 116                                           | 118        | 120        | 121        | 121        | 5                      |
| J. N.          | 132                                           | 132        | 131        | 131        | 131        | — 1                    |
| T. N.          | 117                                           | 125        | 125        | 115        | 115        | 8                      |
| J. S.          | 110                                           | 99         | 103        | 105        | 105        | —11                    |
| B. F.          | 114                                           | 112        | 112        | 110        | 110        | — 4                    |
| A. M.          | 130                                           | 126        | 130        | 130        | 124        | — 6                    |
| I. H.          | 116                                           | 116        | 114        | 116        | 114        | — 2                    |
| E. F.          | 142                                           | 148        | 148        | 144        | 136        | 6                      |
| P. A.          | 144                                           | 146        | 150        | 146        | 136        | — 6                    |
| F. M.          | 114                                           | 114        | 114        | 114        | 114        | 0                      |
| M. G.          | 136                                           | 136        | 144        | 138        | 142        | 8                      |
| W. B.          | 124                                           | 124        | 124        | 122        | 120        | — 4                    |
| W. R.          | 124                                           | 124        | 118        | 120        | 118        | — 6                    |
| X. L.          | 114                                           | 116        | 116        | 114        | 110        | — 4                    |
| A. B.          | 146                                           | 134        | 148        | 132        | 138        | —14                    |
| J. S.          | 100                                           | 90         | 90         | 94         | 100        | —10                    |
| A. H.          | 130                                           | 126        | 126        | 128        | 128        | — 4                    |
| S. G.          | 112                                           | 118        | 116        | 112        | 118        | 6                      |
| M. K.          | 150                                           | 150        | 150        | 148        | 146        | — 4                    |
| L. S.          | 116                                           | 114        | 118        | 114        | 116        | — 2                    |
| J. K.          | 108                                           | 110        | 104        | 104        | 106        | — 4                    |
| M. R.          | 114                                           | 108        | 108        | 106        | 106        | — 8                    |
| S. D.          | 128                                           | 134        | 130        | 130        | 128        | 2                      |
| W. C.          | 130                                           | 130        | 126        | 126        | 124        | — 6                    |
| Av.            | 123                                           | 123        | 123        | 122        | 121        | —2.15                  |
| $\sigma$       | 12.7                                          | 13.6       | 14.8       | 13.4       | 12.0       | 6.25                   |



Table IX

Experiment C

## UNEMOTIONAL LYING

Data for the Truth Group—24 Subjects

| <i>Subject</i> | Readings of Lateral Blood Pressure in mm. Hg. |            |            |            |            | <i>Greatest Change</i> |
|----------------|-----------------------------------------------|------------|------------|------------|------------|------------------------|
|                | <i>1st</i>                                    | <i>2nd</i> | <i>3rd</i> | <i>4th</i> | <i>5th</i> |                        |
| A. H.          | 142                                           | 150        | 148        | 148        | 150        | 2                      |
| H. C.          | 142                                           | 140        | 140        | 140        | 138        | — 2                    |
| I. K.          | 120                                           | 126        | 126        | 132        | 126        | 6                      |
| A. B.          | 160                                           | 164        | 166        | 166        | 166        | 6                      |
| B. S.          | 106                                           | 118        | 116        | 110        | 104        | 12                     |
| A. S.          | 142                                           | 136        | 142        | 146        | 146        | — 6                    |
| M. R.          | 92                                            | 88         | 92         | 88         | 86         | — 6                    |
| J. A.          | 120                                           | 124        | 124        | 126        | 120        | 6                      |
| S. D.          | 146                                           | 138        | 138        | 140        | 138        | — 8                    |
| W. C.          | 140                                           | 142        | 140        | 143        | 140        | 3                      |
| I. R.          | 148                                           | 148        | 148        | 146        | 140        | — 8                    |
| F. G.          | 130                                           | 136        | 136        | 138        | 136        | 8                      |
| X. X.          | 110                                           | 114        | 119        | 112        | 116        | 9                      |
| S. M.          | 142                                           | 142        | 146        | 146        | 152        | 10                     |
| B. C.          | 132                                           | 132        | 132        | 130        | 130        | — 2                    |
| J. H.          | 130                                           | 134        | 132        | 136        | 132        | 6                      |
| T. M.          | 124                                           | 126        | 126        | 128        | 126        | 4                      |
| C. B.          | 124                                           | 118        | 128        | 118        | 114        | —10                    |
| C. M.          | 130                                           | 128        | 128        | 124        | 128        | — 6                    |
| J. W.          | 134                                           | 130        | 138        | 134        | 136        | — 4                    |
| W. B.          | 124                                           | 130        | 124        | 130        | 126        | 6                      |
| F. M.          | 110                                           | 110        | 120        | 114        | 118        | 8                      |
| I. H.          | 118                                           | 114        | 118        | 118        | 116        | — 4                    |
| B. F.          | 118                                           | 120        | 120        | 118        | 118        | 2                      |

Table X

Data for the Deception Group—21 Subjects

| <i>Subject</i> | Readings of Lateral Blood Pressure in mm. Hg. |            |            |            |            |                        |
|----------------|-----------------------------------------------|------------|------------|------------|------------|------------------------|
|                | <i>1st</i>                                    | <i>2nd</i> | <i>3rd</i> | <i>4th</i> | <i>5th</i> | <i>Greatest Change</i> |
| M. P.          | 118                                           | 114        | 114        | 116        | 108        | —10                    |
| I. L.          | 122                                           | 130        | 128        | 132        | 122        | — 8                    |
| S. G.          | 122                                           | 123        | 126        | 130        | 124        | — 8                    |
| S. C.          | 126                                           | 122        | 126        | 120        | 120        | — 6                    |
| D. C.          | 152                                           | 148        | 150        | 148        | 150        | — 4                    |
| J. K.          | 130                                           | 128        | 138        | 138        | 128        | — 8                    |
| L. S.          | 132                                           | 138        | 136        | 138        | 136        | — 6                    |
| N. G.          | 138                                           | 122        | 122        | 128        | 128        | —16                    |
| P. M.          | 134                                           | 140        | 142        | 138        | 142        | — 8                    |
| J. Ki.         | 130                                           | 128        | 130        | 128        | 128        | — 2                    |
| A. S.          | 146                                           | 138        | 140        | 141        | 142        | — 8                    |
| Z. T.          | 128                                           | 120        | 128        | 126        | 126        | — 8                    |
| D. G.          | 142                                           | 138        | 140        | 134        | 134        | — 8                    |
| H. I.          | 138                                           | 142        | 144        | 140        | 138        | — 6                    |
| A. G.          | 150                                           | 150        | 150        | 150        | 140        | —10                    |
| M. F.          | 136                                           | 136        | 132        | 138        | 140        | — 4                    |
| M. G.          | 140                                           | 142        | 142        | 140        | 138        | — 2                    |
| W. R.          | 120                                           | 120        | 120        | 130        | 124        | —10                    |
| P. A.          | 154                                           | 158        | 160        | 154        | 154        | — 6                    |
| D. F.          | 156                                           | 168        | 164        | 150        | 140        | —28                    |
| A. M.          | 138                                           | 138        | 134        | 134        | 134        | — 4                    |

Table XI

RELIABILITY OF THE RESULTS OBTAINED IN THE  
CONTROL DECEPTION TEST

| <i>Reading</i> | <i>Truth</i> |                      |                      | <i>Deception</i> |                      |                      | <i>Reliability</i>    |               |                |
|----------------|--------------|----------------------|----------------------|------------------|----------------------|----------------------|-----------------------|---------------|----------------|
|                | <i>Av</i>    | $\sigma(\text{dis})$ | $\sigma(\text{ave})$ | <i>Av</i>        | $\sigma(\text{dis})$ | $\sigma(\text{ave})$ | $\sigma(\text{diff})$ | <i>R</i>      | <i>Chances</i> |
| 1              | 128.5        | 15.2                 | 3.10                 | 136              | 19.1                 | 2.21                 | 3.80                  | 1.97 $\sigma$ | 1000           |
| 2              | 129.5        | 15.3                 | 3.12                 | 136.6            | 13.4                 | 2.92                 | 4.26                  | 1.67 $\sigma$ | 975            |
| 3              | 130.5        | 15.8                 | 3.22                 | 136              | 10.7                 | 2.33                 | 3.98                  | 1.38 $\sigma$ | 916            |
| 4              | 130          | 13.6                 | 2.78                 | 136              | 9.5                  | 2.08                 | 3.46                  | 1.73 $\sigma$ | 958            |
| 5              | 129.3        | 17.1                 | 3.50                 | 133              | 10.5                 | 2.29                 | 4.17                  | 0.89 $\sigma$ | 813            |

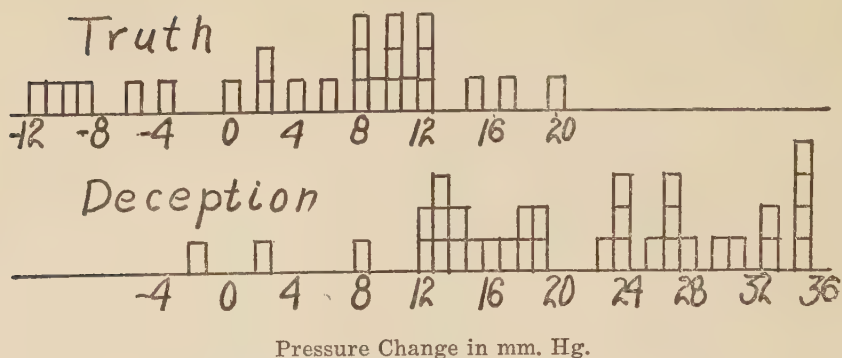


Figure 1.—Distribution of Changes in Truth and Deception.

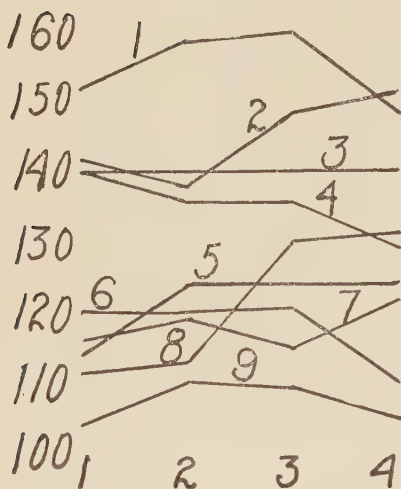


Figure 2.—Curves Showing Individual Differences in the Truth Group.

1. A.K, AS, AW; 2. AS<sup>t</sup>, SG, TN, GP; 3. IR, KD, IK, BS<sup>m</sup>, BC, HJ; 4. BS; 5. IL, JK, WC; 6. VD, MG; 7. CK, JD; 8. JT, BJ, JS; 9. MR.

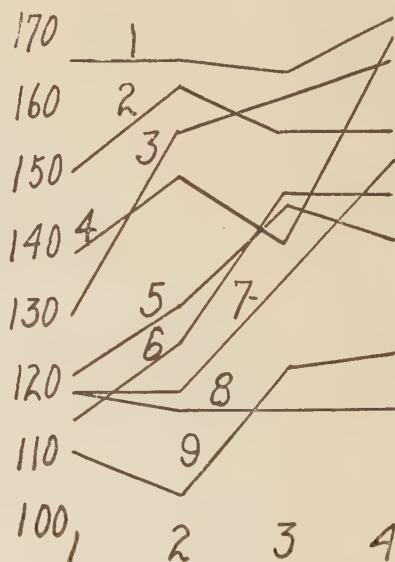


Figure 3.—Curves Showing Individual Differences in the Deception Group.

1. AB, LO; 2. HC, JO; 3. AN, WK, CZ, IR, EB, RC, IL, HL, HS<sup>m</sup>, MH, HS, NP, EW; 4. BM, GM, JE, FR; 5. TK, IS, AH; 6. PF, GS; 7. EF, MK, BM, TL, NG; 8. LB; 9. ME, PK.

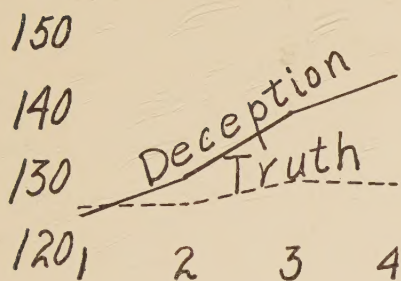


Figure 4.—Group Curves for Truth and Deception.

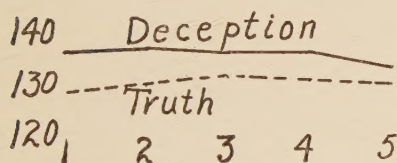


Figure 6.—Group Curves for Unemotional Truth and Deception.

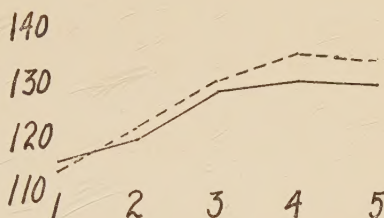


Figure 5.—Group Curve for "Intelligence Test."

Total Group is indicated in the full line.

Group with Ph.D. candidates omitted is indicated by the broken line.

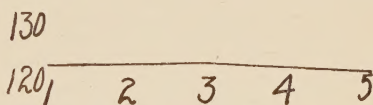


Figure 7.—Group Curve for Mental Work.

## VITA.

Matthew N. Chappell, born in Wakefield, Rhode Island, July 26th, 1900. Bachelor of Science in Electrical Engineering from Rhode Island State College in 1924. Columbia University Scholar 1927-1928, Columbia University Summer School Scholar, 1928. Sigma Xi, 1928. Instructor of Psychology in Columbia University Extension 1927-1928. Instructor of Psychology in Columbia University 1928-1929.







